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Mr. Don A. Ostler
Department of Environmental Quality
Division of Water Quality
P.O. Box 144870
Salt Lake City, Utah 84114-4870

Subject: Net Acid Generation (NAG) Test Results for Humidity Cell Samples, Tailings Impoundment Ground Water Discharge Permit No. UGW350011

Dear Mr. Ostler:

In accordance with the compliance schedule of the Tailings Impoundment Groundwater Discharge Permit Number UGW350011 Kennecott Utah Copper (KUC) is required to perform kinetic net acid generation (NAG) testing on samples from the six humidity cells that were run in 1999 and 2000. The NAG tests have been completed and this letter provides a brief description of the results.

As shown on Table 1, the six humidity cell tailings samples were collected in 1999 from the Copperton Concentrator, Magna Concentrator and from the underflow stream at the cyclone stations. Neutralization potentials were relatively high in 1999 and only one of the six samples had a negative acid/base accounting potential. Sample HT9901 had an acid/base accounting potential of –17 and a neutralization potential ratio (NPR) of 0.4. All of the other samples had ABA potentials of 6 or higher and NPR values of 1.2 or higher. Whenever possible, the NAG tests were run on unmodified and untested tailings sample splits that had been archived, not on the material that had actually been placed in the humidity cell. However, for samples HT9901 and HT9904 no appropriate material was archived so the NAG tests had to be run on tailings that were taken from the humidity cells. The humidity cell test procedure partially oxidized the sulfides in this material and had removed some of the neutralization potential, so these two samples were reanalyzed by the modified Sobek acid/base accounting method as well as being NAG tested.

The temperature and pH results of the kinetic NAG tests are summarized on Table 1 and in Figures 1 through 6. Only the NAG test run on HT9901 acidified. The final pH of this test was 3.09 and the peak temperature was 65.98 degrees centigrade. It took almost 7 hours for the tailings to acidify. The leachate generated from HT9901 also had the highest sulfate, copper and zinc concentrations of any of the six tests (Table 2). The NAG test results for the sample are in good agreement with the ABA potential and NPR results which both predicted that HT9901 should acidify when exposed to surface weathering conditions. As shown on Table 3, the humidity cell for this sample never acidified despite being run for 47 weeks, about twice as long as typical tests.

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None of the other five NAG tests acidified and all had final pH values above 7. The hydrogen peroxide solution typically has a pH of around 5.9 so in each test the pH dropped to around 6 when the solution was first mixed with the tailings sample. For every test except HT9901 the pH then gradually rose during the test. The temperature never exceeded 26 degrees C during any of these tests.

No tailings samples analyzed in a humidity cell by KUC have ever acidified. It is believed that the reaction kinetics in the humidity cells were very slow and that very few of the sulfides were ever oxidized. As expected, sulfide oxidation during the NAG tests is much more rapid. As shown on Table 2, between 27% and 100% of the sulfide sulfur in each sample was converted to sulfate and went into solution. These should be considered minimum values because a significant portion of the sulfate created by sulfide oxidation may have remained in the solid phase of the sample as secondary minerals.

All of the NAG tests were run for at least 24 hours to insure that the hydrogen peroxide was allowed to completely react with any available sulfides. The NAG test protocol states that the test should be run for a minimum of two hours and until all visible effervescing ceases. However sample HT9901 did not begin to acidify until several hours after visible effervescing had ended. To insure that future tests are not ended too soon, KUC recommends that the standard operating procedure (SOP) be modified to state that all tests will be run for 24 hours. It was also noted that when the leachate was being boiled at the end of the test, solids would sometimes precipitate out. In order to get representative concentrations of the dissolved constituents in the leachate, KUC recommends that the SOP text be changed to state that the liquid volume be maintained near 250 ml throughout the boiling process. After pH, conductivity, sulfate, alkalinity and acidity have been analyzed the leachate should then be digested to insure that all metals are returned to solution. KUC also suggests that the following analytical methods be cited in the revised SOP: pH – EPA 150.1, conductivity – EPA 120.1, acidity – Std. Method 2310B and Metals – EPA 200.8.

KUC intends to complete 15 more NAG tests during 2001. The samples selected for these tests will generally have an NPR of less than or equal to one, so it is anticipated that a much higher percentage of these future NAG tests will acidify.

Should you have any questions or comments about these initial NAG test results, please call me at 569-7553 or Rich Borden at 569-7141.

Sincerely,

RJ Borden for

William J. Adams
Director, Environmental Affairs

WJA:cl
Enclosure

Sample #	Sampling Location	Sample Date	AP (1)	NP (1)	ABA (2)	NPR (3)	Paste pH (4)	Initial pH	Final pH	Minutes to pH <4	Initial Temp.(5)	Highest Temp.	Final Temp.	Minutes to High Temp.
HT9901(6)	Copperton	5/3/99	27	10	-17	0.4	7.19	6.02	3.09	405	22.2	65.9	23.4	585
HT9902	Magna	3/2/99	38	44	6	1.2	7.51	6.17	7.56	na	21.3	25.9	24.6	388
HT9903	Underflow	6/30/99	38	59	21	1.6	8.22	6.12	7.53	na	21.5	26.3	25.3	1036
HT9904 (6)	Copperton	4/7/99	7	35	28	2.4	6.93	6.37	7.33	na	21.7	25.2	24.3	942
HT9905 (7)	Magna	9/13/99	19	26	7	1.4	8.31	6.00	7.14	na	21.9	25.8	23.8	811
HT9906 (7)	Underflow	9/13/99	19	26	7	1.4	8.31	6.14	7.73	na	21.5	25.8	25.1	887

(1) Acid Potential (AP) and Neutralization Potential (NP) are expressed in terms of tons $CaCO_3$ per 1000 tons of tailings.
(2) The Acid/Base Accounting (ABA) Potential equals NP minus AP.
(3) The Neutralization Potential Ratio (NPR) equals NP divided by AP.
(4) The paste pH of the sample is measured by mixing distilled water with the tailings at a 1:1 ratio. The initial pH is measured after the hydrogen peroxide (average pH = 5.9) has been added to the sample. The final pH is the pH at the end of the 24 hour test.
(5) All temperature data is in degrees C.
(6) No untested tailings sample was available for NAG testing HT9901 and HT9904. Tailings material that had already been partially oxidized in the humidity cells had to be used in these NAG tests.
(7) The ABA analyses for these samples were rerun. All AP, NP, ABA and NPR values for these samples are averages except for the NP for sample HT9906. For this sample only the second NP result is reported because the first is believed to greatly underestimate NP.

Table 1 - Summary of NAG Test Sample ABA Characteristics and pH and Temperature Data

Sample #	AP (1)	NP (1)	Total Sulfur (2)	Sulfide Sulfur	Solution Sulfate (3)	% total S in Solution (4)	% Sulfide S in Solution (5)	Solution Cu (3)	Solution As	Solution Zn
HT9901	27	10	0.87	0.87	118	100	100	12100	<5	244
HT9902	38	44	1.25	1.21	56	45	43	<20	84	<10
HT9903	38	59	1.30	1.27	37	28	27	36	62	34
HT9904	7	35	0.23	0.23	17	74	74	27	42	31
HT9905	19	26	0.71	0.65	39	55	51	<20	111	18
HT9906	19	26	0.74	0.63	54	73	68	28	59	48

(1) Acid Potential (AP) and Neutralization Potential (NP) are expressed in terms of tons $CaCO_3$ per 1000 tons of tailings.

(2) The total sulfur and the sulfide sulfur in the solid sample expressed in percent.

(3) Sulfate in mg/L and metals in ug/L.

(4) Based upon the sulfate in solution and the mixing ratio of 250 grams of hydrogen peroxide solution for every 2.5 grams of tailings, percentage of the total sulfur removed from the sample can be calculated.

(5) Assuming that all sulfate sulfur is removed from the sample first, this is the amount of sulfide sulfur that must have been converted to sulfate and then went into solution.

Table 2 - Final NAG Leachate Dissolved Constituents and Estimates of Sulfur Removed from the Tailings Samples

Sample #	ABA (1)	NPR (2)	Paste pH (3)	Final Humidity Cell (HC) pH	Final NAG pH	Final HC Sulfate (4)	NAG Sulfate	Final HC Alkalinity	NAG Alkalinity
HT9901(5)	-17	0.4	7.90 (7.19)	6.50	3.09	50	118	5	-29
HT9902	6	1.2	7.51	6.94	7.56	55	56	12	111
HT9903	21	1.6	8.22	7.53	7.53	20	37	20	61
HT9904 (5)	28	2.4	7.67 (6.93)	7.34	7.33	60	17	15	100
HT9905	7	1.4	8.31	7.03	7.14	30	39	10	41
HT9906	7	1.4	8.31	7.52	7.73	27	54	19	81

(1) The Acid/Base Accounting (ABA) Potential equals NP minus AP.

(2) The Neutralization Potential Ratio (NPR) equals NP divided by AP.

(3) The paste pH of the sample is measured by mixing distilled water with the tailings at a 1:1 ratio. The humidity cell pH is the pH of the water draining from the cell during the last week of the test. The final NAG pH is the pH of the hydrogen peroxide solution at the end of the NAG test.

(4) All sulfate concentrations in mg/L. All alkalinity values are in mg/L as CaCO3. A negative value indicates that the solution is acidic and is a measure of the acidity.

(5) No fresh tailings sample was available for NAG testing HT9901 and HT9904. Tailings material that had already been partially oxidized in the humidity cells had to be used in these NAG tests. The first paste pH listed is for the sample before the humidity cell was run. The pH shown in parentheses was measured on the tailings after the humidity cell was completed and before the NAG test was initiated.

Table 3 - Comparison of Humidity Cell and NAG Test Data

Figure 1a - HT9901 NAG Test pH

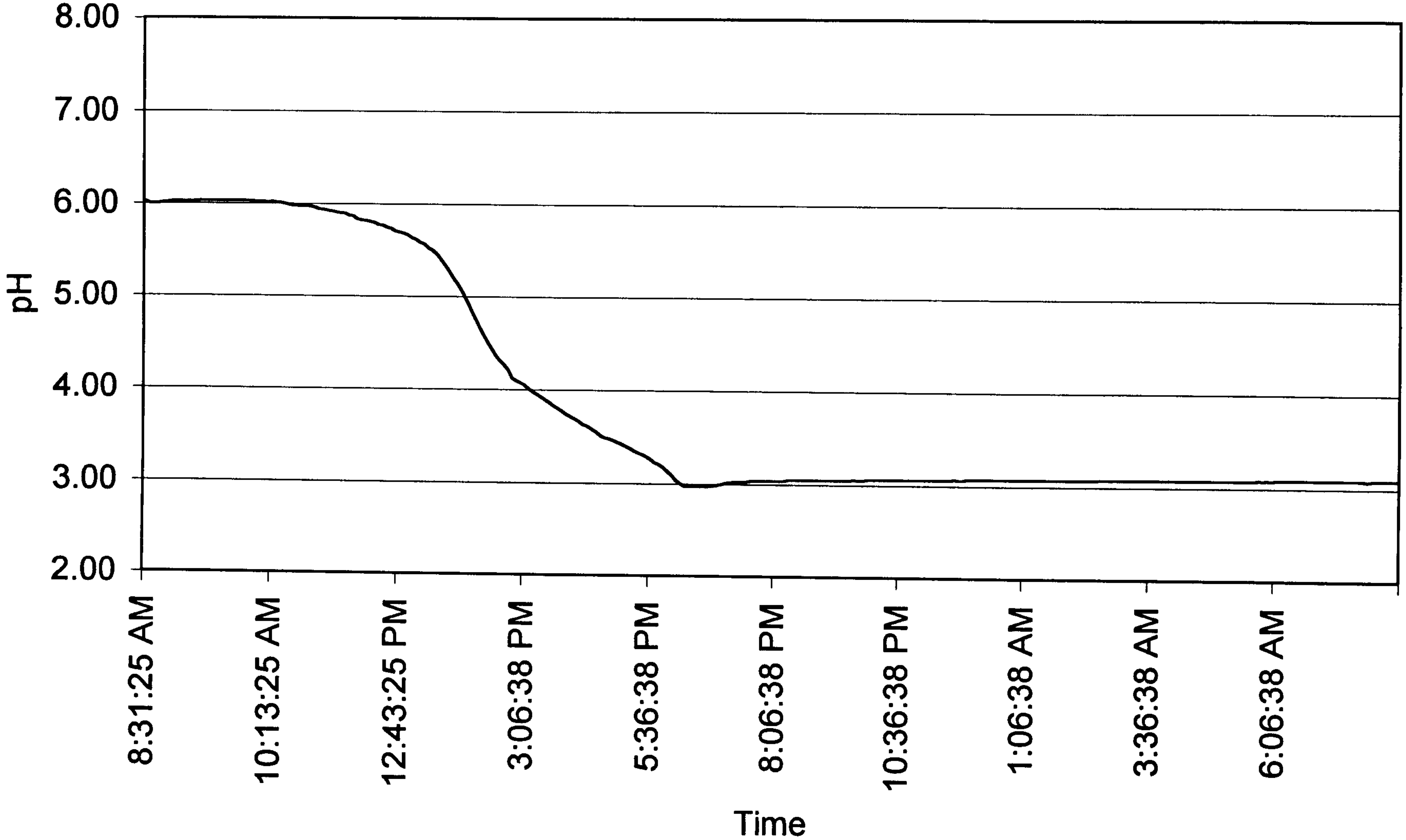


Figure 1b - HT9901 NAG Test Temperature

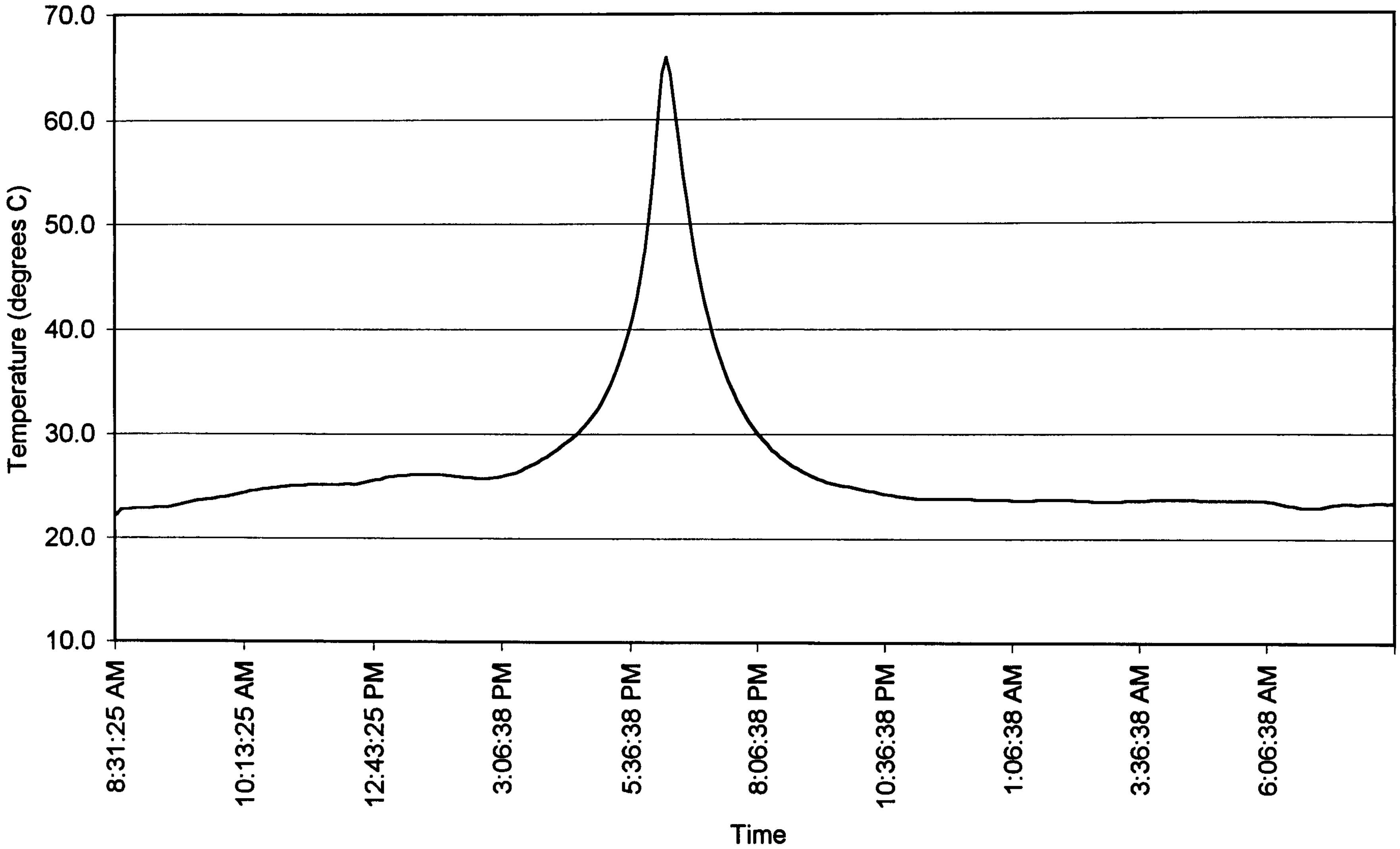


Figure 2a - HT9902 NAG Test pH

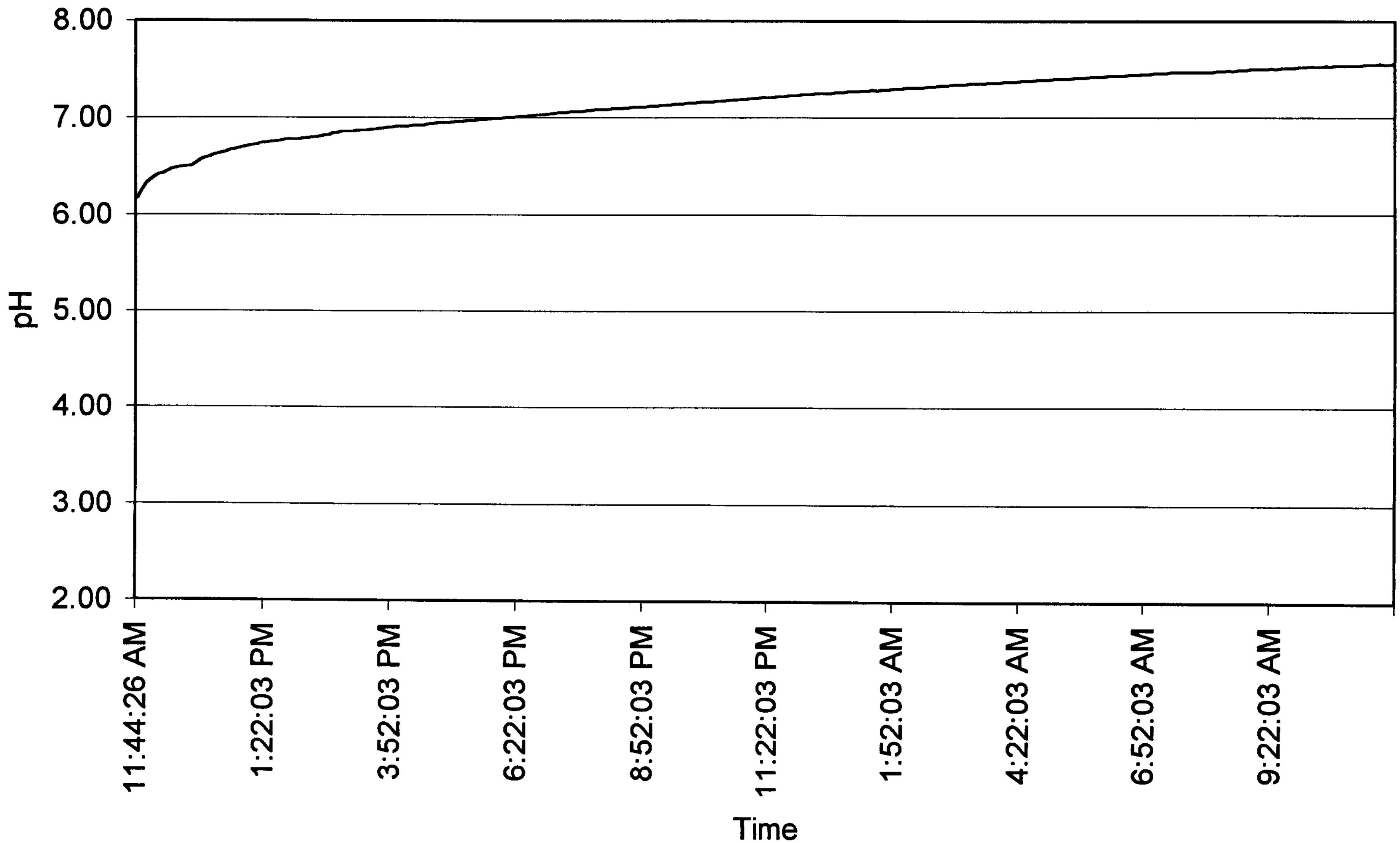


Figure 2b - HT9902 NAG Test Temperature

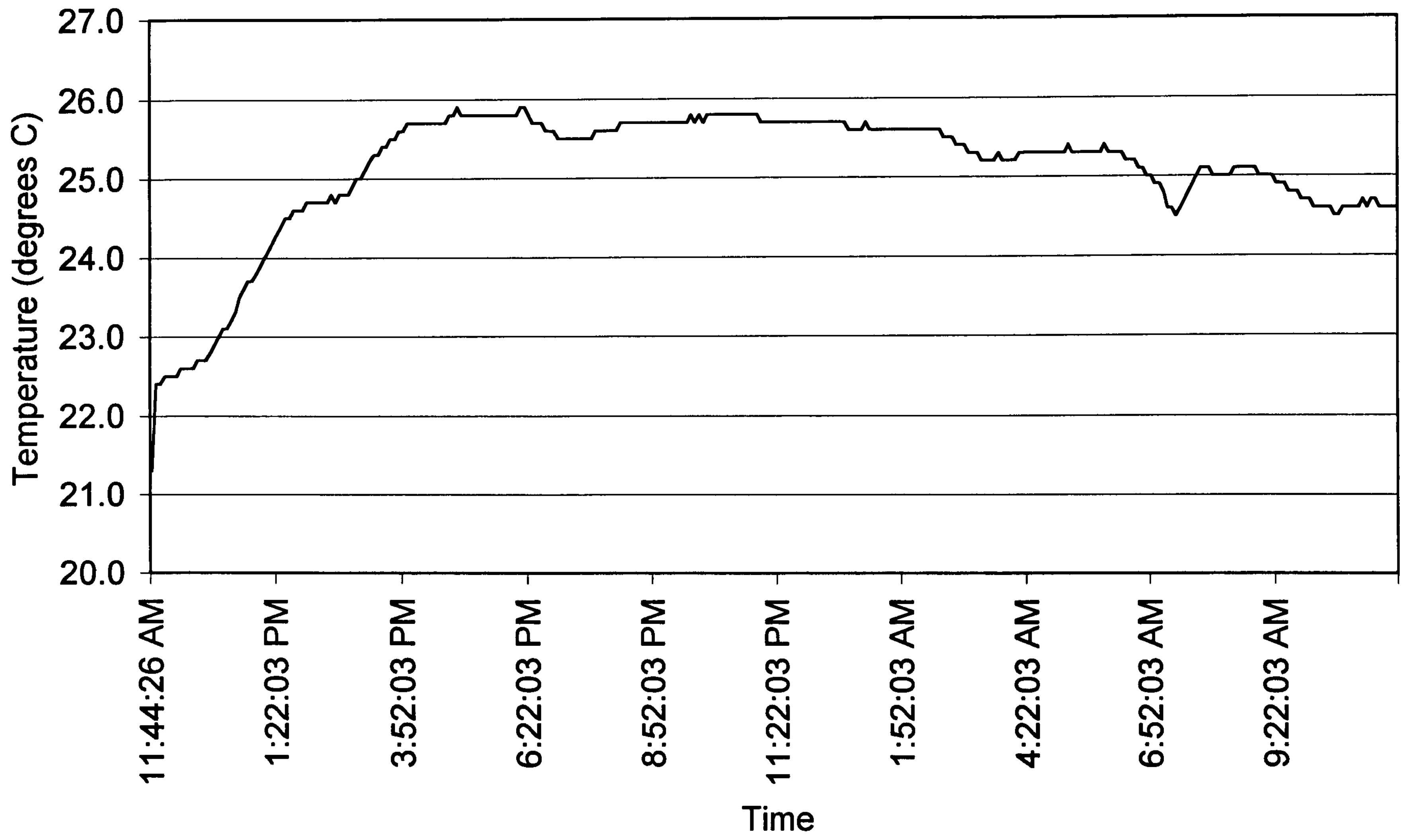


Figure 3a - HT9903 NAG Test pH

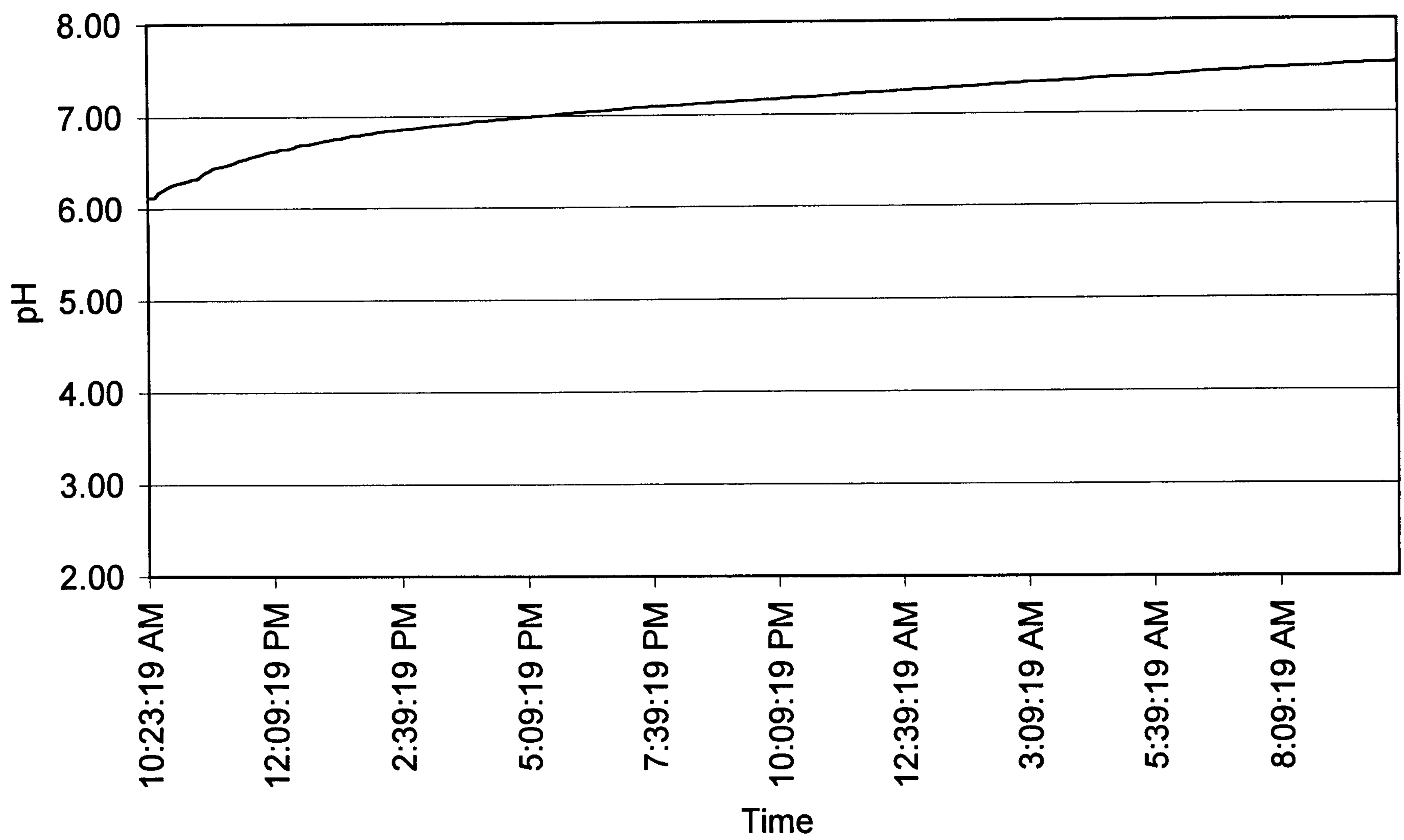


Figure 3b - HT9903 NAG Test Temperature

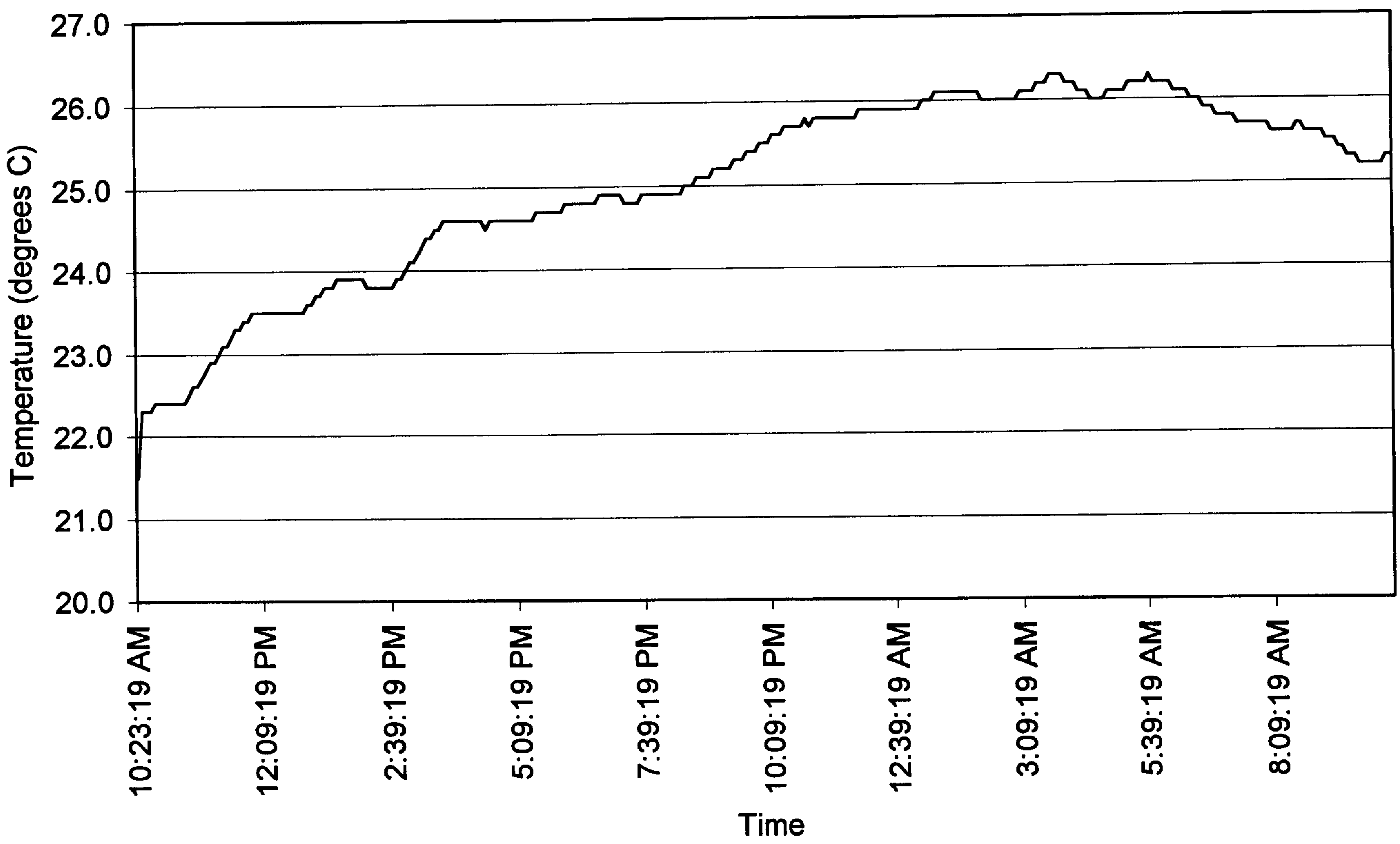
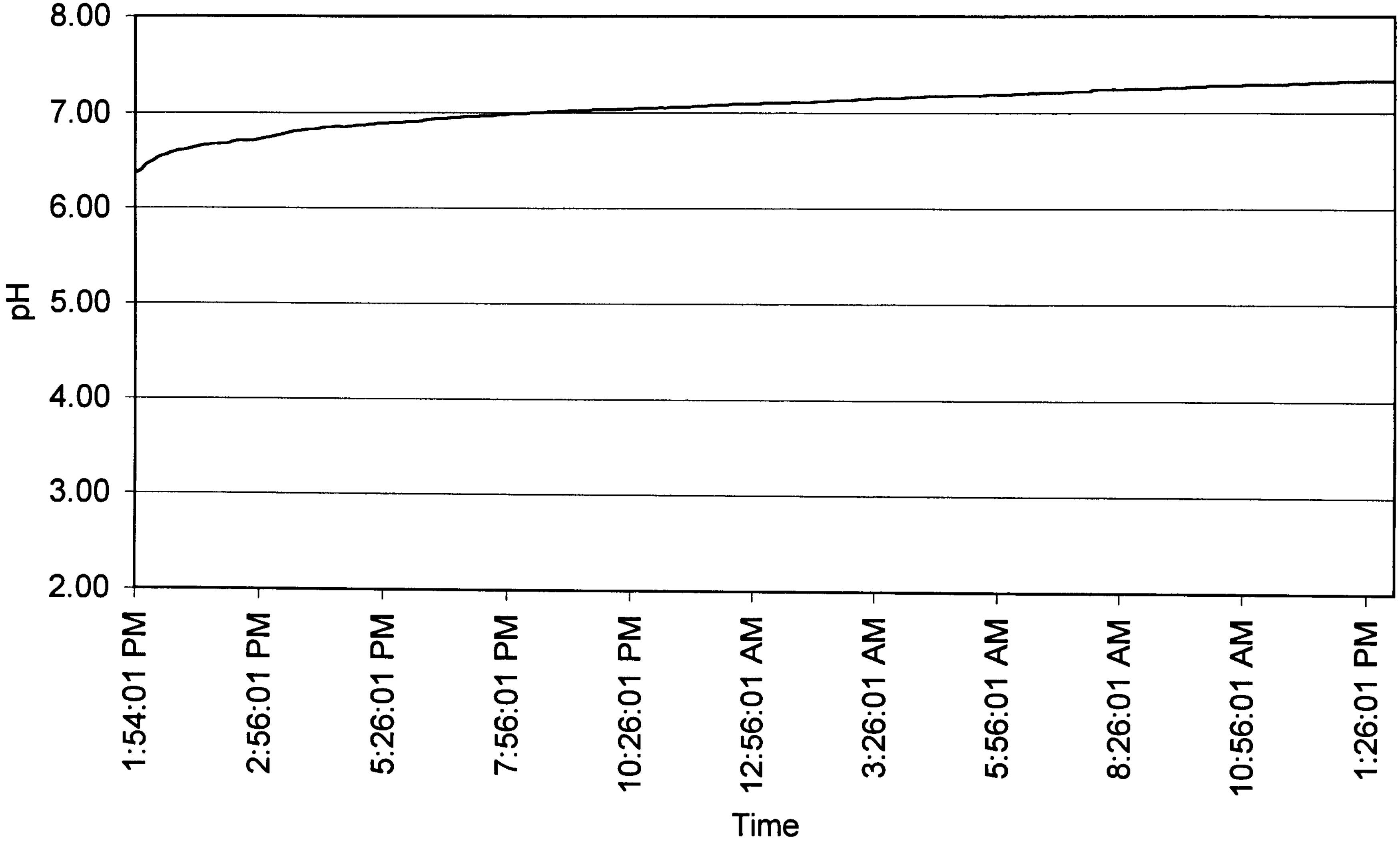


Figure 4a - HT9904 NAG Test pH



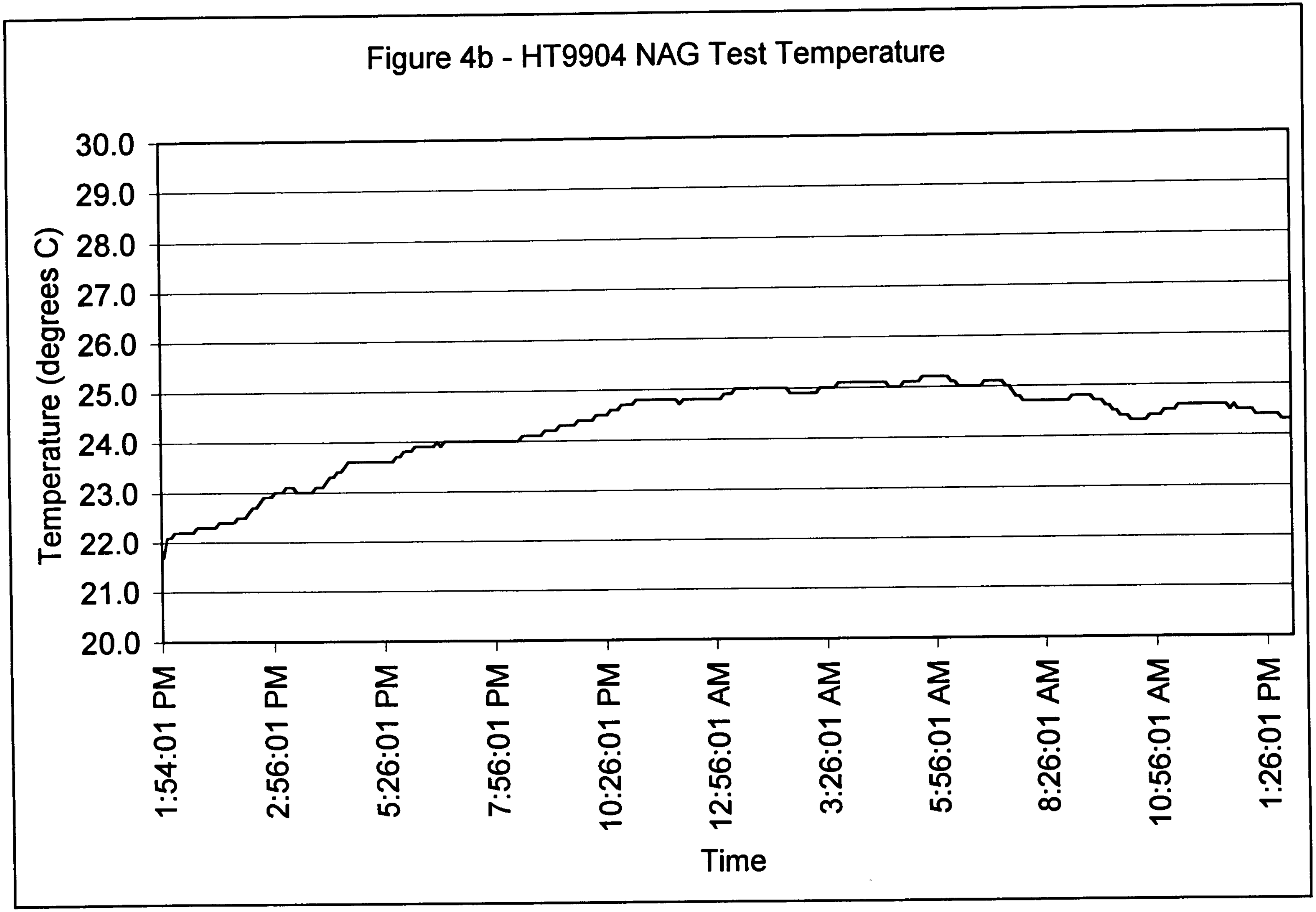


Figure 4b - HT9904 NAG Test Temperature
Temperature (degrees C)
30.0
29.0
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
20.0
1:54:01 PM
2:56:01 PM
5:26:01 PM
7:56:01 PM
10:26:01 PM
12:56:01 AM
3:26:01 AM
5:56:01 AM
8:26:01 AM
10:56:01 AM
1:26:01 PM
Time

Figure 5a - HT9905 NAG Test pH

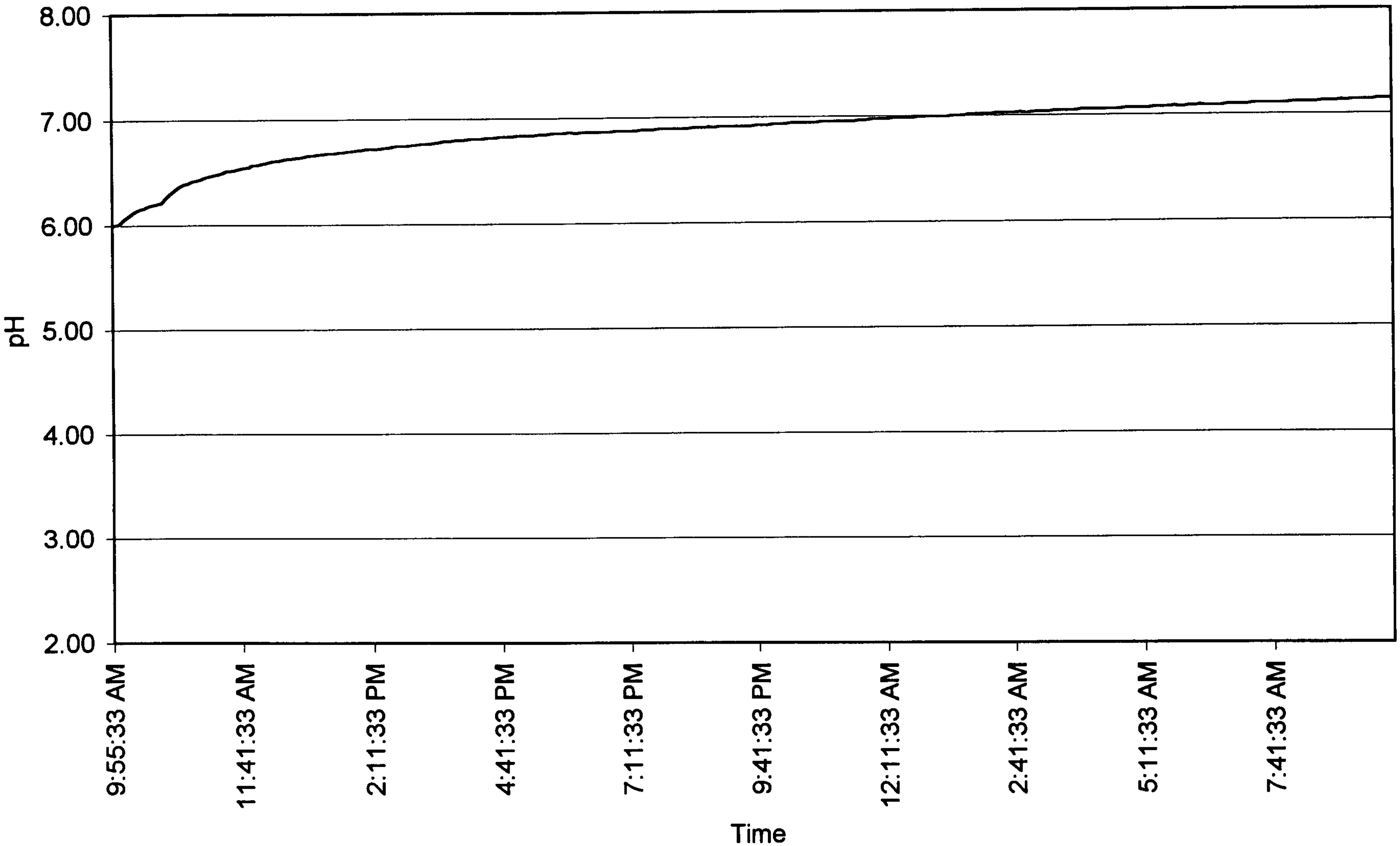


Figure 5b - HT9905 NAG Test Temperature

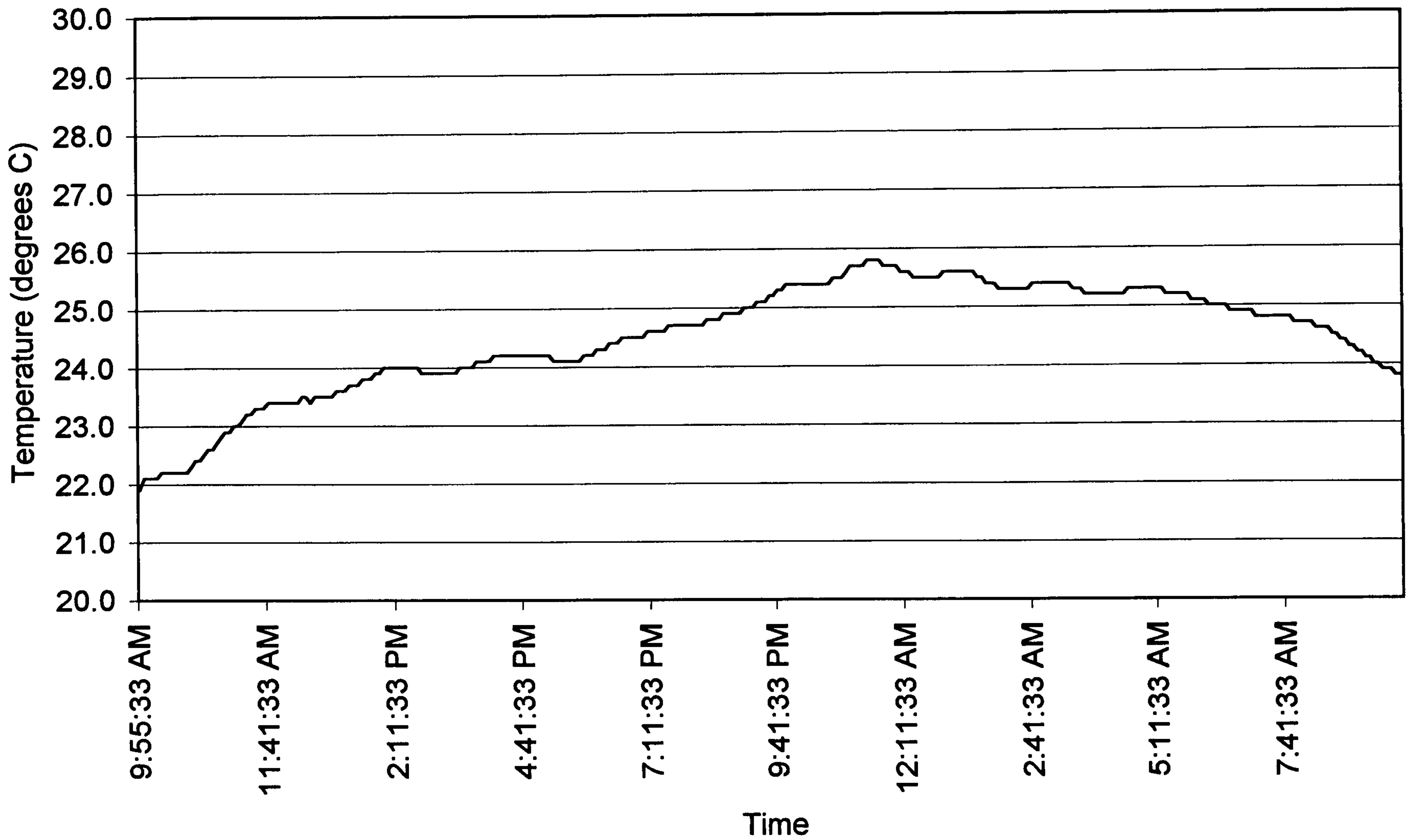
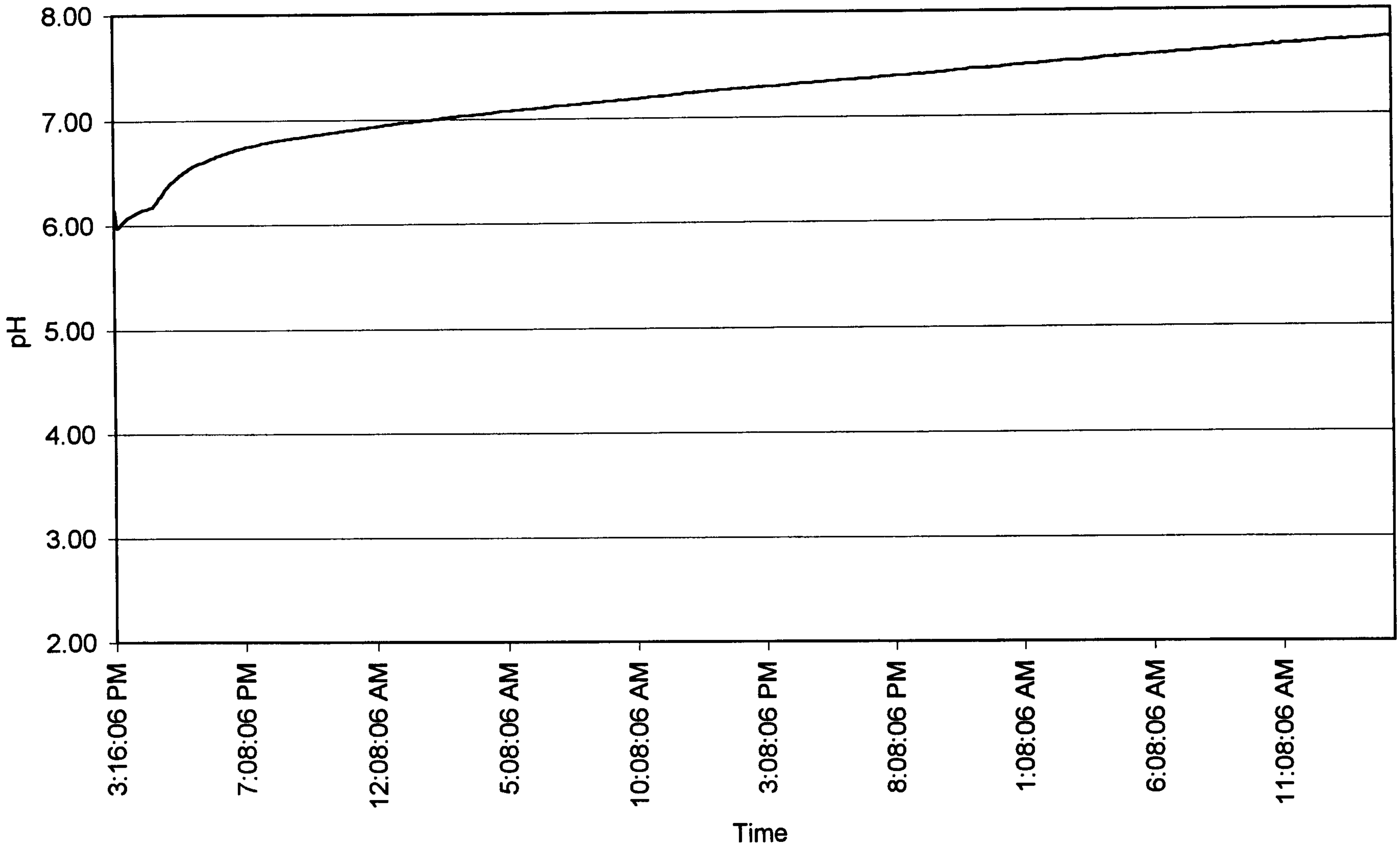


Figure 6a - HT9906 NAG Test pH



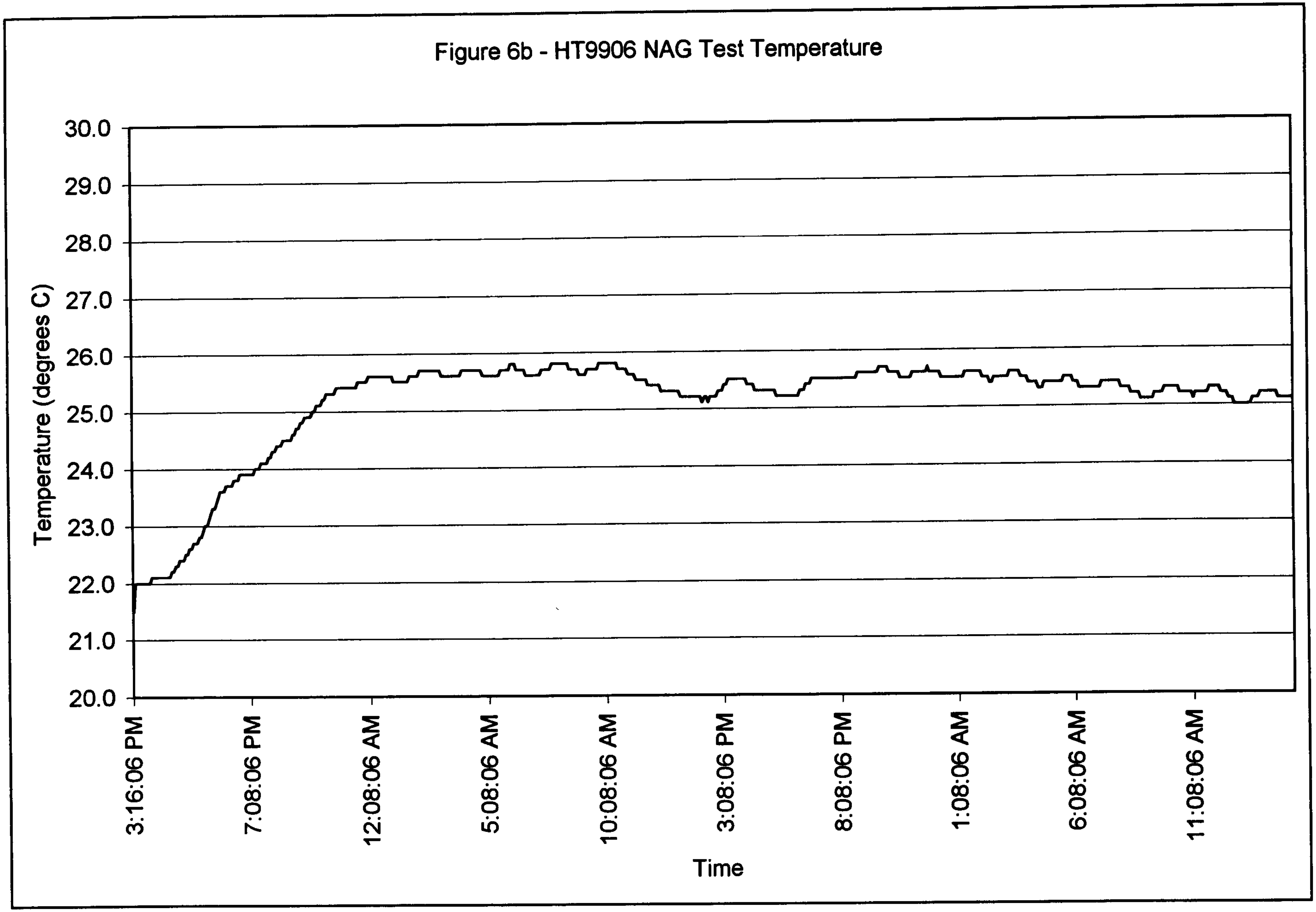


Figure 6b - HT9906 NAG Test Temperature
30.0
29.0
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
20.0
Temperature (degrees C)
3:16:06 PM
7:08:06 PM
12:08:06 AM
5:08:06 AM
10:08:06 AM
3:08:06 PM
8:08:06 PM
1:08:06 AM
6:08:06 AM
11:08:06 AM
Time